PATENT SPECIFICATION

589,071

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PROVISIONAL SPECIFICATION

Improvements in Protective Shields in High-Voltage Apparatus

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and ERICH FRIEDLANDER, of The General Electric Company Limited, Engineering Works, Witton, Birmingham, of German nationality, do hereby declare the nature of this invention to be as follows:—

This invention relates to protective shields in high-voltage apparatus.

When the shape and relative position of two conductors, between which a high-voltage (especially an alternating voltage) may exist, are such that dangerously intense local fields may arise in the space between them, it is usual to separate the conductors by a metal shield insulated from both of them. The shield provides an equipotential surface; by shaping it according to known principles so as to modify suitably the mutual capacitance between the shield and the conductors, the local fields can be smoothed out and the danger arising from them avoided.

This device is very effective in preventing (e.g.) corona from points and sharp corners; but, as it has been used hitherto, it is subject to certain disadvantages. Thus, if there are two weak spots in the insulation between the conductors, one extending from one conductor through most (but not all) the insulation and the other extending similarly from the other conductor, these weak spots may be innocuous, in the absence of the shield, so long as they lie some distance apart; but if the shield extends from one weak spot to the other, a path is opened from one conductor to the other through the two weak spots in series. Again, if a weak place develops momentarily in the insulation, the whole of the energy stored in the capacitor of which the shield forms one plate is available to maintain a discharge through the weak spot; the discharge may therefore be so intense that the insulation may be damaged permanently. Again, if the local dangerous field lies near a boundary where the general field changes suddenly (for example, at the transition of the conductors from the slot to the overhang of an alternator) it may be difficult to find a shape for the shield which, while smoothing out the dangerous local field, does not produce another dangerous field near the said boundary.

The object of this invention is to mitigate some or all of these disadvantages. It can be attained by sub-dividing the shield into a number of parts separated by distances sufficient to prevent discharges passing between adjacent parts, but near enough to prevent any considerable penetration of an electrostatic field between the parts.

According to the invention a protective shield in high voltage apparatus comprises a plurality of metal parts, all insulated from each other, and adjacent bodies are separated from each other by distances comparable with the dimension of at least one of the adjacent bodies, measured in the direction of their closest approach.

Certain embodiments of the invention will now be described, by way of example, with reference to the accompanying drawing in which each figure refers to a different embodiment.

Figure 1(a) shows a standard condenser bushing, which is not according to the invention. Here 1 is a metal rod passing through a hole in a metal plate 2 and, where it so passes, coated with insulation 3. A set of protective shields 4 is embedded in the insulation, each being a tube concentric with the rod, the length of the tube (and therefore the area of the shield) being greater the nearer the shield is to the rod. Figure 1(b) shows the bushing modified according to the invention. Each tubular shield is divided longitudinally into a plurality of separate elements, such as 5, 6, 7, 8, 9, 10, 11 which replace the outer tube 4 in *a*. The structure shown in *b* can be produced thus. The rod 1 is wrapped with a layer of insulation. On the outside of this layer rings of conducting material are formed (e.g. by painting) constituting the inner most shield; another layer of insulation is then wrapped on the rod, and rings are formed on it; and so on.

In Figure 2 the turns 12, 13, 14 of a winding in a slot in the armature of a HV alternator 15 are shown in cross section at *c* and in side elevation at *d*. The winding is wrapped with insulation 6, in which are

embedded two conducting shields 17, 18 one outside the other. This is known if each shield is continuous. According to the invention, the shields are sub-divided into rings by planes perpendicular to the axis of the winding, as shown at 19, 20, 21 in *d*. The rings can be formed on each layer of insulation as it is formed, as explained with reference to Figure 1.

In Figure 3, 22 is a copper conductor of a transformer, covered with insulating tape 23, which passes near a constructional member of the transformer (not shown). Corona is then liable to occur between the constructional member and those parts of the insulation 23 which overlie the corners of the conductor. This corona can be mitigated or prevented as is known, by a protective shield of suitable shape outside the insulation. According to the invention this shield is made up of the conducting edges of annular discs, such as 24, threaded on the insulation. The disc may be slit, as shown at 25, to enable them to be so threaded. The discs 24 with conducting edges are spaced from each other by discs 26 having no conducting edges. The conducting material on the edge may be graphite or metal. The discs need not be all similar, so that the shield is cylindrical; a shield of conical or other shape can be built up by the use of discs of different sizes. However, also discs of the same size and shape may sometimes be used in the case of the field undergoing changes along the conductor because the subdivision of the shield makes automatically a local adjustment of the shield voltage possible.

The inner as well as the outer edges of the annular discs may be conducting, so that two shields are formed one within the other. Again adjacent discs may both have a conducting edge or edges, so long as adjacent conducting edges are not near that a discharge may pass between them. Thus two or three shields, one within the other may be provided by forming a conducting surface on the outer or outer and inner edges of one set of discs and on the outer edges of another set of different outer dimensions, and threading members of the two sets alternately on the conductor.

Dated the 27th day of March, 1942.

For the Applicants,

A. F. CORNOCK,

Chartered Patent Agent.

COMPLETE SPECIFICATION

Improvements in Protective Shields in High-Voltage Apparatus

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British company, and ERICH FRIEDLANDER, of The General Electric Company Limited, Engineering Works, Witton, Birmingham, of German nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to protective shields in high-voltage apparatus.

When the shape and relative position of two conductors, between which a high-voltage (especially an alternating voltage) may exist, are such that dangerously intense local fields may arise in the space between them, it is usual to separate the conductors by a metal shield insulated from both of them. The shield provides an equipotential surface; by shaping it according to known principles so as to modify suitably the mutual capacitance between the shield and the conductors, the local fields can be smoothed out and the danger arising from them avoided.

This device is very effective in preventing (e.g.) corona from points and sharp corners; but, as it has been used hitherto, it is subject to certain disadvantages. Thus; if there are two weak spots in the insulation between the conductors, one extending from one conductor through most (but not all) the insulation and the other extending similarly from the other conductor, these weak spots may be innocuous, in the absence of the shield, so long as they lie some distance apart; but if the shield extends from one weak spot to the other, a path is opened from one conductor to the other through the two weak spots and the shield in series. Again, if a weak place develops momentarily in the insulation of a conductor, the whole of the energy stored in the capacitor of which the shield forms one plate and the conductor the other is available to maintain a discharge through the weak spot; the discharge may therefore be so intense that the insulation may be damaged permanently. Again, if the local dangerous field lies near a boundary where the general field changes suddenly (for example, at the transition of the conductors from the slot to the overhang of an alternator) it may be difficult to find a shape for the shield which, while smoothing out the dangerous local field, does not

produce another dangerous field near the said boundary.

The object of this invention is to mitigate some or all of these disadvantages.

According to the present invention, in high voltage apparatus, a protective shield arranged to provide a substantially equi-potential surface is sub-divided in the surface into a plurality of separate conducting elements all the elements being of substantially the same size and insulated from one another and the minimum distance between adjacent elements is so chosen that whilst the distance is sufficiently small for a substantially equi-potential surface to be provided by the separated elements, it is sufficiently large to prevent a discharge or partial breakdown between one element and another to cause breakdown of the gap between the elements.

Certain embodiments of the invention will now be described, by way of example, with reference to the drawing accompanying the provisional specification in which Figure 1a shows a standard condenser bushing and Figures 1b, 2c and 2d, and 3 show different embodiments.

Referring now to the drawing, Figure 1a shows a standard condenser bushing, which is not according to the invention. The bushing comprises a conductor 1 passing through a hole in a metal plate 2 and, where it so passes, coated with insulation 3. A set of protective shields 4 is embedded in the insulation, each being a tube concentric with the conductor 1, the length of a tube (and therefore the area of a shield) being greater the nearer the shield is to the conductor 1. Figure 1b shows the bushing modified according to the present invention. Each tubular shield is divided longitudinally into a plurality of separate elements, such as 5, 6, 7, 8, 9, 10, 11 which replace the outer tube 4 in Figure 1a and are insulated from one another. The structure shown can be produced thus. The conductor 1 is wrapped with a layer of insulation. On the outside of this layer rings of conducting material are formed (e.g. by painting) constituting the innermost shield; another layer of insulation is then wrapped on the conductor 1 and its insulation and rings are formed on it; and so on. The axial length of the rings decreases with increase in their diameter.

In Figure 2c, the conductors 12, 13, 14 in a slot of a high voltage alternator 15 are in section at right angles to their length whilst in Figure 2d, a side section of the conductors is shown. Each conductor is wrapped with insulation 16, in which are embedded two conducting shields 17, 18 one outside the other. Previously, such shields have been continuous and according to the present invention, the shields are sub-divided into rings by planes perpendicular to the axis of the conductor, as shown at 19, 20, 21 in Figure 2d. The rings can be formed on each layer of insulation as it is wound, as explained with reference to Figure 1b.

In Figure 3, a laminated copper conductor 22 of a transformer is covered with insulating tape 23 and passes near a metallic constructional member of the transformer (not shown). Corona is then liable to occur between the constructional member and those parts of the insulation 23 which overlie the corners of the conductor. This corona can be mitigated or prevented as is known, by a protective shield of suitable shape outside the insulation. According to the present invention, this shield is made up of the conducting edges of annular discs of insulating material, such as 24, threaded on the insulation. The disc may be slit, as shown at 25, to enable them to be so threaded. The discs 24 with conducting edges are spaced from each other by discs 26 having no conducting edges. The conducting material on the edge may be graphite or metal.

The inner as well as the outer edges of the annular discs 24 may be conducting, so that two shields are formed one within the other. Again, adjacent discs may both have a conducting edge or edges, so long as adjacent conducting edges are not so near that a discharge may pass between them. Thus two or three shields, one within the other, may be provided by forming a conducting surface on the outer edge, or on the outer and inner edges, of one set of discs and on the outer edges of another set of large outer dimensions, and threading members of the two sets alternately on the conductor.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. High voltage apparatus, wherein a protective shield arranged to provide a substantially equi-potential surface is sub-divided in the surface into a plurality of separate conducting elements all the elements being of substantially the same size and insulated from one another and the minimum distance between adjacent elements is so chosen that whilst the distance is sufficiently small for a substantially equi-potential surface to be provided by the separated elements, it is sufficiently large to prevent a discharge or partial breakdown between one element and another to cause breakdown of the gap between the elements.

2. High voltage apparatus according to

Claim 1, wherein the said elements have such a form that they could have been produced by removing parts from a set of tubular elements co-axial with each other and with a high voltage conductor.

3. A high voltage alternator according to Claim 1, wherein the said elements all surround a conductor in a slot and are annuli spaced along the said conductor.

4. A high voltage apparatus according to Claim 1, wherein the said elements lie on the edges of discs, separated by discs having non-conducting edges, through which a high voltage conductor is threaded.

5. High voltage apparatus comprising a protective shield or shields having parts constructed and arranged substantially as hereinbefore described with reference to Figures 1b, 2 or 3 of the drawing accompanying the provisional specification.

Dated the 5th day of December, 1945.
For the Applicants,
A. F. CORNOCK,
Chartered Patent Agent.

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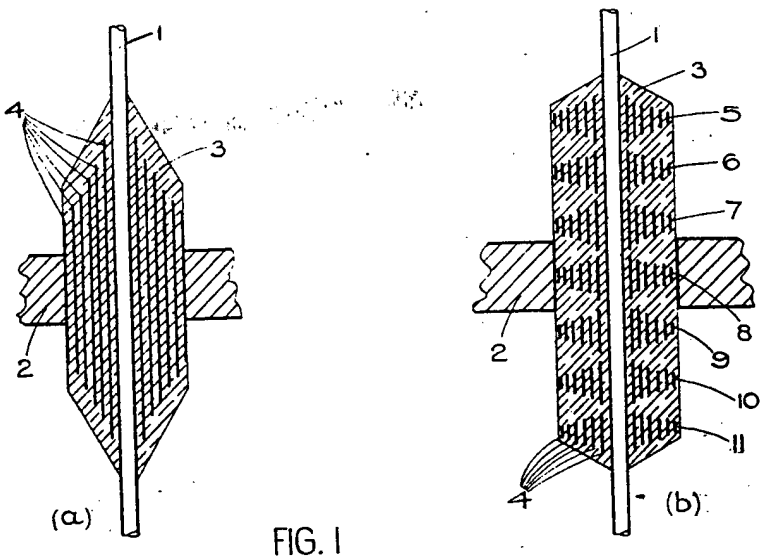

FIG. 1

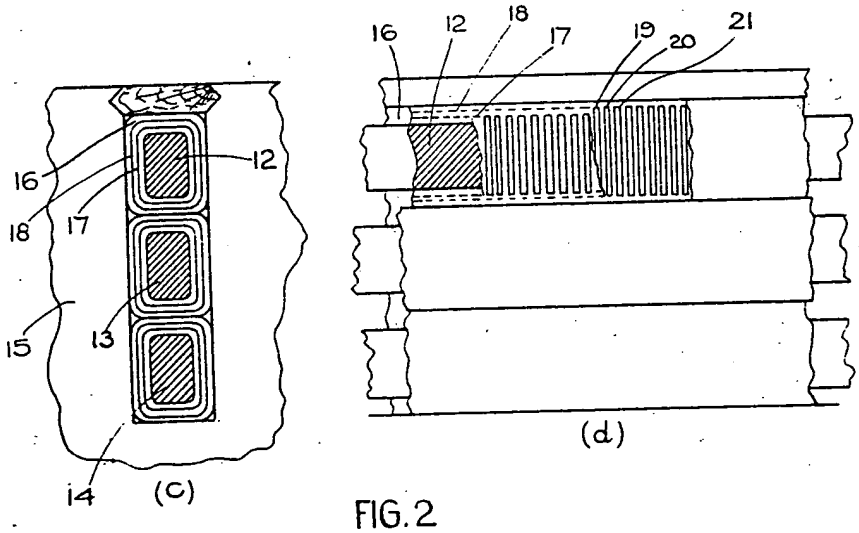

FIG. 2

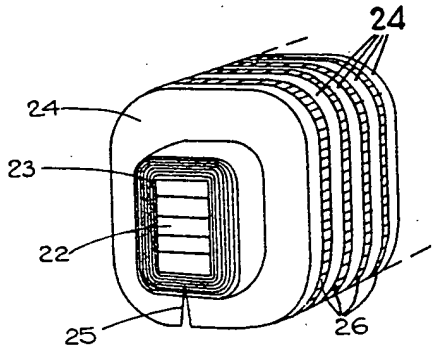

FIG. 3

H.M.S.O.(Ty.P.)